Watershed Investigations

by Alec Bodzin and Louise Shive

Investigating local watersheds presents middle school students with authentic opportunities to engage in inquiry and address questions about their immediate environment. Investigation activities promote learning in an interdisciplinary context as students explore relationships among chemical, biological, physical, geological, and historical characteristics of the watershed. This helps them to understand changing trends in water quality, which can encourage students to formulate conclusions about the impact of land and water use and habitat issues. In addition, historical research of a watershed may help students understand changes and develop possible solutions to protect their watershed.

Students can use web-based learning resources to assist them in their watershed investigations. This article describes our specific project design and provides guidelines for teachers considering conducting their own watershed investigations.

The LEO EnviroSci Partnership

In our case, we began collaborating with a group of teachers who were working with the Wildlands Conservancy, a nonprofit group dedicated to river preservation and environmental stewardship that had been monitoring the water quality of the Lehigh River and its tributaries. Students from area classrooms collected water quality data and teachers wanted their students' data to be used by area scientists involved in water quality monitoring efforts. However, a quality control mechanism had to be in place to ensure that data would be reliable and accurate. The teachers were also interested in exposing their students to current water quality research and related studies by area scientists. In a partnership with the Wildlands Conservancy, the Lehigh Earth Observatory (LEO, a multidisciplinary program that monitors and studies the planet, its environmental systems, and how they interact with human society) was providing Earth and environmental science data sets and collection activities to the public on their website (see Resources). So, a partnership was created to enhance the existing environmental science curricula of schools by developing an educational website to assist students in their studies of the local watershed.

Instructional goals

Through collaborative design meetings, the group developed curricular materials to ensure that the activities would be aligned to instructional goals—specifically that students would understand the "bigger picture" of how ecosystems work, participate in an authentic scientific investigation using authentic data, and learn in an interdisciplinary context that emphasized scientific discovery of the local environment. The teachers stressed the importance of having students understand how to contrast different types of collected data and analyze and interpret data on different time scales. In addition, students should gain an understanding of the environmental factors that produce observed data.

The collaboration also involved the development of an extensive website, LEO EnviroSci Inquiry (see Resources). Learning resources were created to assist students in collecting data, analyzing data, and working with Global Information Systems (GIS) databases. Aligned with the *National*

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Science Education Standards, the *Benchmarks for Scientific Literacy*, and state standards, the curricular activities that were created emphasize student-directed scientific inquiry relative to their local environment. The website includes:

- background information and protocols associated with water quality,
- assistance for using Vernier CBL (Calculator-Based Laboratory) units and graphing calculators to collect water quality data,
- data reporting forms, virtual watershed tours, digital images, etc., and
- interdisciplinary connections.

A local watershed study

In our watershed study, participating middle school teachers received training from LEO on the use of technology such as CBL probeware and calculators for water quality data collection. During the school year, students conducted seasonal sampling field trips to a creek location and investigated questions about their watershed. During the sampling field trips, students used probeware to measure a variety of chemical and physical properties, ions, and nutrients including pH, conductivity, temperature, chloride, calcium, ammonium, dissolved oxygen, and nitrates. Macroinvertebrate sampling was also conducted. Once they returned from the creek visits, students submitted their data using the web-based data report form. The data is now part of a larger database that can be viewed online.

At the end of the school year, students completed the Dissolved Oxygen activity (see Resources) that uses a reduced data archive to allow students to investigate the relationship between dissolved oxygen and temperature from data recorded from four different local areas. Students graphed the data and analyzed existing patterns to determine the relationship between the two water quality parameters. The activity provides links to explanations provided by water quality experts that permitted students to evaluate their explanations in light of alternative explanations. They were then instructed to create a poster presentation to communicate their findings to the class.

Conducting your watershed investigation

We have learned a great deal from our experience with conducting middle-level watershed investigations. Here is a framework to assist in planning similar experiences for your students to work with authentic data.

Motivating contexts: Provide students with a motivating entry point to set the stage for investigation. Use a locally relevant problem or real-life situation that students can easily experience. Such motivating contexts provide them with reasons to learn more about the water quality in their watershed. For example, motivating contexts used in our watershed investigations include acid drainage from abandoned coal mines, a toxic waste site near a local town, and the siltation of a local creek from runoff from new housing developments.

Selecting a sampling site: When selecting a sampling site, consider the physical access to the site. Can it be reached by foot or motor vehicle? Does the sampling site permit public access or is special permission required? Be sure to keep in mind the following safety considerations when selecting a site:

- Is the flow rate or movement of the water body too strong or too deep for a student to stand in?
- Is the approach to the sampling area flat or sloped?
- Is the area generally free of irritating plants such as poison ivy?
- Are there sudden changes in depth close to the shore?
- Are there any disease causing organisms in the water?
- Will students be able to wear proper footwear?
- Do the conditions allow for wearing safety glasses?

Safety issues should be discussed with students prior to visiting the creek. In our watershed area, we work closely with scientists that regularly monitor the streams and tributaries to make sure that students are not sampling in highly contaminated areas.

Gathering data: Protocols for sampling need to be developed or provided. The following factors should be well thought out prior to gathering field samples:

- Sampling techniques—What is an appropriate way to collect a sample? It is important that students know and practice sampling techniques before working in the field. A good sample is usually obtained in the middle of a stream well below the surface of the water.
- Availability of data collection tools—What are the proper tools to use for data collection? Decide on which data collection tool should be used for a given parameter. Chemical test kits and probeware may both be used for data collection. It may also be appropriate to conduct a macroinvertebrates survey to assess the health of a water body. (See Tech Trek in the January 2004 and November 2003 issues of *Science Scope* for information on the latest probeware and data collection tools.)
- Quality assurance and quality control—How do you know that your data are reliable and accurate? To assure that probeware equipment is functioning properly, a calibration should be performed. When using chemicals, be sure to check that stock solutions are not out of date. When collecting field data, students need to follow the specific directions of a protocol exactly as described. Keep track of samples. Be sure that a good recording system is established for labeling samples and recording data.

- Preparing for the sampling trip—What do you need to bring with you when you sample? This could include plastic sampling bottles with lids for water collection, deionized water for cleaning instruments, extra batteries when working with probes, permanent markers and labels for sample bottles, fine nets for macroinvertebrates, magnifying glasses, collection trays for macroinvertebrates, waders for cold weather and leech-infested waters, data sheets or a hand-held device such as a Palm Pilot to record data, and yardsticks and rulers for measurements.
- Selecting a time to sample—When should you sample? Be aware that some chemical nutrient data produce different values depending on the time of day. How often can you sample? Although a richer data set can be produced with multiple sampling excursions during a school year, noticeable patterns may be observed with only three seasonal sampling trips.
- Selecting variables to test—Which variables can be tested? Which variables should be tested? Consider your access to equipment and your curricular time constraints.
- Sampling safety—If you are interested in sampling from an area that is highly contaminated, or if the weather is very cold, a sample could be collected by dropping a bottle over the side of a bridge and lowering it to the water. Such sampling protocols are available online at *www.leo.lehigh.edu/projects/waterquality/sampling.html*. Also, consider contacting your state water or environmental safety agency if you are unsure about the safety of a sampling location.

CAUTION

Analyzing data: Consider the following factors when determining how data will be analyzed:

- Time scale issues—How much data needs to be analyzed in order to formulate a conclusion? What can students learn from a data set taken at one point in time? Students may require a large enough data set to observe seasonal variations or annual patterns in a water body in order to formulate a conclusion.
- Comparing other variables—Which water quality variables will be compared? What do the relationships mean? Some water quality variables such as dissolved oxygen and temperature have an inverse relation.
- Data representation—How do you represent your data? Should data be placed in a spreadsheet? A graph? A GIS? Be sure to include units and make sure students understand what the units mean. Units must be consistent for students to compare data from different parts of the watershed.
- Scope of the data—How do your data relate to other locations in the watershed? Watersheds are large interconnected systems. Students should think about how their collected data relate to the watershed as a whole.
- Data patterns—What patterns do you observe? Does one variable seem to be related to another? Is this what you would expect to see? Why or why not? What about the outliers? Where do they come from? Why? Can you see changes over time?
- Contributing your data to a larger data set—Data collection must be consistent with acceptable protocols. Consider how data will be shared. E-mail and submissions to web-based forms may be used. It is often helpful to view data on a website or a spreadsheet application. When working with large data sets, look for obvious trends in the data.

Investigating alternative explanations: Prompt students with questions to think about investigating alternative explanations. There are many information sources where they can access relevant scientific knowledge that might lead them to alternative conclusions or explanations. Information may be found in scientific journals, websites, and newspaper articles. Be sure that resources are accurate and reliable.

Communicating conclusions and/or explanations: What content needs to be communicated to your audience? Decide if students should select their method of communication or be presented with a layout that guides their presentation. When selecting an appropriate format, have students decide who the intended audience is and how conclusions should be displayed. Communication formats might include a traditional scientific poster, an oral report, a news article, a newscast, a website, or a lab report.

Summary

Our collaborative partnership was viewed as a success for everyone involved. Watershed investigations provide students with opportunities to explore relationships among the chemical, biological, physical, geological, and historical characteristics of their watershed. Similar partnerships can provide a mechanism for classroom teachers and students to utilize technology-based tools and resources to which they might not otherwise have access, as well as the opportunity to contribute to a larger scientific database. Our collaborative efforts have shown that these investigations can be successful vehicles for assisting teachers in implementing watershed exploration in their classrooms and motivating students to do real science with real data in the real world. ■

Resources

LEO website—*www.leo.lehigh.edu*
LEO EnviroSci Inquiry—*www.leo.lehigh.edu/envirosci*
Dissolved Oxygen activity—*www.leo.lehigh.edu/envirosci/water*